INTERPRETATION OF POST-MORTEM MICROBIOLOGY CULTURES: RETROSPECTIVE ANALYSIS OF CHILDREN UNDER FIVE YEARS OF AGE FROM 2011-2015 IN ONTARIO

By

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ABSTRACT: A retrospective analysis of sudden unexpected child deaths under five years of age was performed at the Ontario Forensic Pathology Service, Ontario, Canada in an attempt to correlate post-mortem microbiological test results to post-mortem macroscopic and microscopic findings. The study focused on a five year period between 2011 and 2015 for a total of 284 cases, of which 180 were of undetermined cause. A spreadsheet was compiled including bacterial and viral findings, autopsy findings, and final diagnosis. All data was extracted from a central computerized pathology database and manually entered into a separate spreadsheet. Microbiological and cause of death data was assigned a presence or absence score in the form of a one or zero. Spearman correlation coefficients were calculated for each potential combination using a correlation matrix. Correlation coefficients above 7.0 and below -7.0 were considered significant. The significance of microbiological specimens in undetermined causes of death was investigated in this study.

KEYWORDS: forensic science, forensic pathology, post-mortem bacteriology, post-mortem virology, sudden unexpected death in childhood

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CHAPTER 1

INTRODUCTION AND BACKGROUND

1.1 Introduction and Statement of Problem

Sudden unexpected death in seemingly healthy children is rare, however, when it occurs, the death often remains unexplained after a thorough post-mortem investigation (Tümer *et al.,* 2005). The significance and association of bacteria and viruses in sudden unexpected deaths in children under five years of age remains unknown (Weber *et al.,* 2008). Studies typically focus on sudden unexpected death in infancy of children less than two years of age (SUDI), and sudden infant death syndrome (SIDS), which includes only children aged less than one year old (Weber *et al.,* 2010). Sudden death in children over one year of age has been of little focus in the literature (Tümer *et al.,* 2005). It is for this reason that this study was designed to focus on all sudden and unexpected deaths occurring in children under the age of five.

1.2 General Background

In approximately one third, or less, of child death cases, the post-mortem examination and review of the clinical history and death scene yield a cause of death, known as explained sudden unexpected death in childhood (SUDC), whilst the remaining majority remain unexplained (unexplained SUDC) (Weber *et al.,* 2010). Sudden death in childhood is most often

non-natural, and is typically either accidental, or due to homicide (Tümer *et al.,* 2005). The average incidence of sudden unexplained death in infancy in Canada ranges between 4.8 and 5.1 per 1,000 live births per year, with Ontario's range falling between 4.7 and 5.3 per 1,000 live births per year (Statistics Canada, 2015). Statistics Canada, however, does not specifically report sudden unexpected death statistics for children over the age of one.

Previously, infection has been suggested as a potential cause or important mechanism in sudden unexpected child deaths, usually based on a combination of histopathological and microbiological findings (Weber *et al.,* 2010). Therefore, facilities often incorporate mandatory microbiological and histological sampling in cases of child and infant deaths. Interpretation of bacteriological and virological samples is straightforward if a significant pathogen is isolated in association with pathological evidence of inflammation (Morris *et al.,* 2007). This interpretation, however, can be much more difficult if a common organism is found in a case where death was rapid and inflammation has not developed (Morris *et al.,* 2007). This is particularly true for cases of sudden unexpected death in infancy and childhood. A confident diagnosis can rarely be made on the basis of bacteriology or virology alone, and, although potentially subtle, corroborative evidence of infection must be sought (Morris *et al.,* 2007).

Some suggest that many currently unexplained sudden unexpected child deaths may be related to infection, possibly mediated by abnormal systemic immune responses to otherwise transient bacterial infections (Weber *et al.,* 2010). The "common bacterial toxin hypothesis" postulates that some sudden infant death syndrome (SIDS) cases may be caused by bacterial toxins, most likely produced by upper respiratory tract organisms such as *Staphylococcus aureus* (Harrison *et al.,* 1999). In the National Institute of Child Health and Development SIDS

Cooperative Epidemiological Study, 29% and 44% of SIDS infants had evidence of an upper respiratory infection (URI) within 24 hours and two weeks before death, respectively (Hoffman *et al.,* 1988).

Many risk factors have been identified for unexplained sudden unexpected death in childhood (SUDC), including prone sleeping, co-sleeping and maternal smoking, as well as high ambient room temperatures, excessive clothing and/or bedding, and head covering (Hoffman *et al.,* 1988). As a way of explaining the association between these diverse risk factors and unexplained SUDC, the "triple risk hypothesis" was developed. The triple risk hypothesis suggests that in these cases, death occurs as a consequence of the concurrent interaction of three factors: an intrinsically vulnerable infant, a critical developmental period, and exposure to exogenous stressors (Weber *et al.,* 2010). This model therefore suggests that sudden child death may be the result of different aetiologies that share a final common pathway, rather than there being a single common cause (Weber *et al.,* 2010).

1.3 Goals of Study

The aim of this retrospective study was to determine the role of post-mortem microbiology in establishing a cause of death in children under the age of five whose autopsies were performed between 2011 and 2015 in Ontario, and causes of death were deemed undetermined. This study also examined any other associations between causes of death that were not undetermined and their corresponding microbiological yields. This project serves as a

contribution to the current research being done into the causation of sudden unexpected death in infants and children.

CHAPTER 2

MATERIALS AND METHODS

2.1 Data Collection

A retrospective analysis of 284 autopsy and microbiological findings of sudden unexpected child deaths between the ages of zero and five years was undertaken at the Office of the Chief Coroner of Ontario (OCC) in Ontario encompassing a five year period, 2011-2015. All sudden unexpected, non-violent deaths occurring between one hour and five years of age were included. In each case, the medico-legal autopsy was performed by a specialist in forensic medicine in a regional or provincial forensic pathology center or hospital. In total, autopsies considered in this study were performed by 48 forensic pathologists. All autopsies were performed in Ontario, with the exception of 13 cases which were performed in Winnipeg, Manitoba for reasons of cost and convenience. All autopsies were performed according to a common standard operating procedure (SOP), which included external examination, internal examination via the LeTulle Technique, histological sampling of all major organs, ancillary investigations such as virological and bacteriological sampling, and any necessary specialist investigations (see Appendix I). Routine microbiological samples were taken from blood, cerebrospinal fluid, lung and spleen, while routine virological samples were taken from nasopharynx and lung. Additional samples were taken when deemed necessary by the reporting forensic pathologist.

A spreadsheet was compiled including date and location of autopsy, post-mortem interval (days), sex, age at death (months), details of medical history and circumstances of death, microbiological and virological findings, autopsy findings and final diagnosis. All data was extracted from a central computerized pathology database and manually entered into a separate spreadsheet. The computerized pathology database was titled the "Death under Five Folder" by the Officer of the Chief Coroner of Ontario and contained four folders separated by year of case completion. Table 2.1 displays the distribution of cases within each folder.

Table 2.1: Case distribution and inclusion by folder year as designed by the Office of Chief Coroner of Ontario.

Folder Year	Number of Cases in Folder	Number of Cases Included	Cases without Microbiology Testing	Cases without Autopsy	Other Excluded Cases
2015	134	90	6	28	10
2014	105	87	2	9	7
2013	60	51	3	2	4
2012	93	56	1	3	33

For the purposes of this study, microbial isolates were categorized into one of three groups: non-pathogens (organisms that are usually non-pathogenic), group one pathogens (organisms which would be interpreted as significant or probably significant and are usually associated with an identifiable focus of infection) and group two pathogens (organisms which would be interpreted as significant, or possibly significant, but may not necessarily be associated with an identifiable focus of infection) (Weber *et al.,* 2008). These pathogenic categories were used to determine if and when a bacteria and/or virus could be classified as

causing death. Only specimens obtained during post-mortem investigation were included and microbiological results were restricted to bacterial and viral cell culture results only.

In all cases, the microbiological results were classified into three categories based on their potential contribution to the death. Microbiological results were categorized as: causing death, post-mortem overgrowth/contamination, or normal flora, as per instruction from the supervising forensic pathologist. These categories were defined with no reference to the results of post-mortem microbiological sampling, to avoid bias. All cases were identified in the database by an assigned study number only.

2.2 Statistical Analysis

All relevant information was categorized into groups and each group assigned a number. For example, the location at which the autopsy took place was assigned a number, with nine locations, and therefore, nine groups resulting. The nine locations included are as follows; the Ontario Forensic Pathology Service, the Hospital for Sick Children, Mount Sinai Hospital, University of Western Ontario Hospital, the Eastern Forensic Pathology Unit, the Children's Hospital of Eastern Ontario, the Hamilton Regional Forensic Pathology Unit, the North Eastern Regional Pathology Unit and the Winnipeg Health Sciences Center. For cause of death and microbiological data, a presence or absence score in the form of a one or zero was assigned based on a chosen keyword (See Appendix II). A sample section of the keyword search and scoring sheet can be seen in Figure 2.1. The correlations between combinations of causes of death, virology and bacteriology were assessed using a correlation matrix created in Microsoft

Excel 2010. Correlation coefficients above 0.70 and below -0.70 were considered statistically significant. However, there were no negative correlations below -0.70 present. Therefore, only positive correlations were further analysed.

Table 2.2: Sample section of keyword search spreadsheet with assigned presence and absence scores.

Assigned Case Number	Undetermined	Heart Failure	Metabolic Acidosis	Herpes Simplex Virus	Acute Asthmatic Attack
1	0	1	0	0	0
2	0	0	1	0	0
3	1	0	0	0	0
4	0	0	0	1	0
5	0	0	0	0	1
6	1	0	0	0	0
7	0	0	0	0	0
8	0	0	0	0	0
9	1	0	0	0	0
10	0	1	0	0	0

CHAPTER 3

RESULTS

3.1 Results

Of the 284 case reports analysed in this study, 180 (63.38%) had causes of death classified as undetermined, while only 38 (13.38%) had microbial or viral causes of death. That being said, all cases analysed demonstrated the presence of bacteria and/or viruses in at least one cultured sample type. The distribution of undetermined and microbial/viral causes of death by year of study can be seen in Table 3.1.

In terms of age groups, 223 (78.52%) cases occurred in children aged one year or less, 37 (13.03%) cases occurred in children aged between one and two years, 16 (5.63%) cases occurred in children aged between two and three years, 5 (1.76%) cases occurred in children between the ages of three and four years, and 3 (1.06%) cases occurred in children between the ages of four and five years. In this study, the vast majority of sudden unexpected deaths occurred in children aged one year or less. This is in accordance with the statistics which demonstrate the crude rates of sudden unexpected death in infancy and childhood in the United States of America between 2011 and 2015 (Table 3.2).

In converting the data to binary, 69 causes of death (see Appendix II), 142 species of bacteria (see Appendix II), and 18 types of viruses (see Appendix II) were used as keywords to determine the presence or absence of each in all cases. Upon creation of a correlation matrix, 84 total correlations were identified as being above the coefficient cut-off of

0.70 occurring between any combination of cause of death, bacteria and/or viruses. Of these 84 correlations, 33 were isolated as occurring between a cause of death and a bacteria or virus. No correlations above 0.70 were identified as being between an undetermined cause of death and a bacteria or virus.

Table 3.1: Number and percentage of deaths classified as undetermined and microbial/viral per year of autopsy.

Year of Autopsy	Undetermined Cause of Death	Microbial/Viral Cause of Death
2015	3/10 (30.00%)	6/10 (60.00%)
2014	25/63 (39.68%)	11/63 (17.46%)
2013	56/89 (62.92%)	11/89 (12.36%)
2012	48/67 (71.64%)	7/67 (10.45%)
2011	48/55 (87.27%)	3/55 (0.055%)

Table 3.2: Crude rates of SUDI and SUDC/100,000* in the USA between 2011 and 2015 (https://sudc.org/sudc-facts/statistics).

Year	Under 1 year	Age 1-4 years	Age 5-9 years	Age 10-14 years	Age 15-19 years
2011	69.7	1.5	0.1	0.1	0.4
2012	69.6	1.4	0.2	0.1	0.6
2013	66.4	1.4	0.1	0.1	0.5
2014	66.8	1.3	0.1	0.1	0.4
2015	69.6	1.4	0.2	0.2	0.5

*Death rates for infants less than one year of age are calculated per 100,000 live births; death rates for children over the age of one are age adjusted per 100,000 children.

3.1 Summary of Results

A total of 284 cases were analysed, where 108 had undetermined causes of death and 38 had causes of death related to infection. The majority (78.52%) of cases occurred in children aged 1 year or less. A total of 229 parameters were selected in the conversion of the dataset to presence and absence scores. These were used to create a correlation matrix with a coefficient cut-off of 0.70. The results indicate 33 positive correlations occurring between a cause of death and a bacteria or virus (see Appendix III).

CHAPTER 4

DISCUSSION

4.1 Discussion

The isolation of bacteria from post-mortem samples can arise in four ways; a genuine positive, agonal spread, translocation and contamination (Morris *et al.,* 2007). A genuine positive result occurs when the bacteria have invaded the body in life and were present at the time of death. Bacteraemia can occur in life without causing symptoms or significant disease, but if bacteraemia is followed by death then one cannot exclude the possibility that it is a contributing factor to death (Morris *et al.,* 2007). Agonal spread is only a theoretical concept and has not been proven. It is hypothesized that during the agonal process or in a period where circulation is artificially maintained by resuscitation, there is relative ischemia/hypoxia of mucosal surfaces allowing bacteria to invade (Morris *et al.,* 2007). Since there are many different types of bacteria present on the mucosal surfaces of humans, the growth, theoretically, should be mixed. Post-mortem translocation describes a process where bacteria can grow on a mucosal surface after death and after the circulation has ceased (Morris *et al.,* 2007). These bacteria can then invade the body and the blood. This is the basic concept of putrefaction, which occurs normally after death if the body is not refrigerated (Morris *et al.,* 2007). Agonal spread and translocation can occur during post-mortem resuscitation and can contribute to abnormal bacterial findings. Contamination occurs when bacteria were not present in the body at the time of autopsy but were introduced when a sample was obtained (Morris *et al.,* 2007). The determination of the manner of bacterial and viral introduction into

the body is beyond the scope of this study. As such, the focus will remain on the types of bacteria and viruses present and their relationship to the cause of death of the child.

From this study, 142 different species of bacteria and 18 types of viruses were isolated and identified. The manner in which these bacteria and viruses were deposited in the body is unknown, and should, therefore, not automatically be interpreted as contaminants (Krous *et al.,* 2003). It is equally important, however, that these positive cultures not necessarily be interpreted as pathogens if there is an absence of supporting ante-mortem clinical illness and/or post-mortem histological evidence of infection (Krous *et al.,* 2003). Although bacteria and/or viruses were isolated from every case analysed in this study, only 38 cases had causes of death that could be directly attributed to specific microbiology. This is likely due to the aforementioned criteria where an absence of histological evidence or ante-mortem illness failed to corroborate infection.

The presence of certain bacterial species can be considered contributory to the cause of death, as certain bacteria are known to always, or almost always, represent true bacteremia, as opposed to being from contamination (Weinstein, 2003). Microorganisms that always, or nearly always (>90%), represent true bacteremia include *Staphylococcus aureus*, *Streptococcus pneumoniae*, *Escherichia coli* and other members of the *Enterobacteriaceae*, *Pseudomonas aeruginosa*, and *Candida albicans* (Weinstein, 2003). *Streptococcus pyogenes*, *Streptococcus agalactiae*, *Listeria monocytogenes*, *Neisseria meningitidis*, *Neisseria gonorrhoeae*, *Haemophilus influenzae*, members of the *Bacteroides fragilis* group, *Candida* species other than *C. albicans*, and *Cryptococcus neoformans* are known to always, or virtually always, represent true infection (Weinstein, 2003). In contrast, microorganisms such as *Corynebacterium* species,

Bacillus species other than *B. anthracis*, and *Propionibacterium acnes* represent true bacteremia very rarely (Weinstein, 2003). In this study, 50.00% (19/38) of the infection related deaths were attributed to a bacterial or viral type that is considered to always or almost always represent true bacteremia. The remaining 50.00% either occurred in post-resuscitation efforts, in combination with other bacteria and/or viruses, or in combination with a separate, non-infectious pathology.

It was observed that 63.38% of the cases analysed in this study were left undetermined. Although all cases of undetermined cause of death reported positive bacterial and/or viral cultures, there was no other ante-mortem or post-mortem evidence to support an infectious cause of death. The presence of bacteria and/or viruses where the cause of death is non-infectious can be due to contamination or post-mortem overgrowth; however, since the pathogenesis of sudden unexpected death in childhood is unknown, microorganisms cannot be confirmed as contamination or overgrowth. Thus, the cases that were deemed undetermined could not be correlated to any particular bacteria or virus present in culture, but microbiological specimens cannot be completely ruled out as a contributor to sudden unexpected death in childhood.

4.2 Statistical Limitations

A major limitation is that, although the sample size of this dataset is quite large, the smaller sample variability may have interfered with the statistical analyses performed. In calculating correlations, those that were above 0.70 were highlighted. However, a large portion

of these correlations that met this criterion showed 100% correlation. This may be due to artefact while trying to take qualitative data and convert it to a binary or quantitative format. In certain cases excel only had one scenario to evaluate in which a particular correlation occurred. Therefore, if there is only one instance of a particular correlation to evaluate, the scenario is scored 1/1 and will be assigned a 100% correlation, or a correlation coefficient of 1. This is suspected to be due to the lack of appropriate cases matching a given criteria.

This study also only applies to Ontario. This limits the available sample size and may not apply to other countries dues to differences in autopsy protocols and different microbiomes and infectious diseases.

By far the largest statistical limitation of this data is that it is qualitative, binary data. The original autopsy and microbiology reports were converted to presence and absence scores of one or zero. Having only ones and zeros to manipulate has drastically decreased the statistical options available for analysis. Although correlations were performed using Microsoft Excel, the possibility of more accurate analysis using more sophisticated programs is currently under investigation.

CHAPTER 5

CONCLUSIONS

5.1 Summation

In summary, the presence of bacteria and viruses in the body can occur in different ways and does not always contribute to death. There is no discernable method for determining whether positive culture results represent true bacteremia or contamination. Therefore, the presence of bacteria and/or viruses of sufficient pathogenicity must be corroborated with a record of ante-mortem clinical illness and/or the presence of post-mortem histological evidence of infection.

All cases examined in this retrospective study reported either positive bacterial or viral culture results, or both. Deaths that were considered to be of microbial or viral consequence showed bacterial and viral species that were always or almost always considered to represent true infection of 50.00% of the cases. The remaining 50.00% of cases related to microbial or viral causes occurred in combination with other factors which, in combination led to death.

Although positive bacterial and/or viral cultures occurred in every case analysed, no statistically significant correlations were made between undetermined causes of death and bacteria or viruses.

5.2 Conclusions and Recommendations

This study concludes that there is no statistically significant correlation between undetermined causes of sudden unexpected death in childhood and bacterial or viral isolates cultured at autopsy. Therefore, based solely on the findings of this study, the pathogenesis of sudden unexpected deaths in childhood remains unknown and cannot be attributed to bacteria or viruses.

To improve this study, a larger sample size and an effort to obtain quantitative data may increase the accuracy of the statistical analysis. Expanding the study to include other provinces and territories in Canada may address these issues. A more precise form of statistical analysis may provide more precise results. A type of factor analysis, mainly principal components analysis is currently under investigation as an alternative means of analysis for this dataset.

APPENDIX I

Standard Operating Procedure

Postmortem Examination Practices

P-PRO-PFPU-06.01

THIS DOCUMENT IS AUTHORIZED FOR USE EFFECTIVE:			Date
	Name	**Position**	**Signature**
Prepared By:	M. Arias and M. Currie, Taylor Gardner, T. Monk and S. Santangelo	Autopsy Services Coordinator and Forensic Pathologist's Assistants	Signatures on File
Reviewed By:	J. Arnold	Manager, Forensic Services	Signature on File
Authorized By:	Dr. J. Herath	Forensic Pathologist	Signature on File

6.0 PURPOSE:

To guide new employees or to refresh existing employees working at the OFPS about postmortem examination practices at this facility.

6.1 SCOPE:

This document applies to PAs and Pathologists.

6.2 INTRODUCTION:

This document includes instructions on how to complete various postmortem examinations including: external, internal, criminally suspicious (i.e. homicides), death under five years, decomposed/mummified, infectious, and chemically hazardous.

There are four major techniques to complete the internal examination method:

1) Virchow Technique, where the organs are removed one by one and dissected as removed
2) Rokitansky Technique, where organs are dissected in situ
3) LeTulle Technique, where all the organs are removed en masse and dissected into organ block, and

4) En Bloc Technique, where the organ block is removed by physiological function (i.e. thoracic and abdominal).

The preferred method used at OFPS is the LeTulle Technique, which will be described in detail below.

6.3 DEFINITIONS:

Petal Method: This method does not require use of the oscillating saw. If the sutures of the skull are not fused (i.e. infants), use scissors to cut through the sutures and then carefully pull back the 4 bone sections (2 frontal and 2 parietal/temporal) far enough that the brain is accessible. Remove brain as per routine.

6.4 ABBREVIATIONS:

ABFO = American Board of Forensic Odontologists

ALS = Alternate Light Source

EDTA = Ethylenediaminetetraacetic acid

OFPS = Ontario Forensic Pathology Service

PA(s) = Pathologists' Assistant(s)

PAPR = Powered Air Purifying Respiratory

6.5 REFERENCES:

Body Fluid Exposure or Needlestick Injuries Standard Operating Procedure (P-PRO-GEN-02.01)

Brain Fixation Standard Operating Procedure (P-PRO-PFPU-04.01)

Completion of the Autopsy Standard Operating Procedure (P-PRO-PFPU-07.01)

Guidelines on Autopsy Practice for Sudden Unexpected Deaths of Infants and Children Under 5 Years, January 2009. Queen's printer for Ontario, 2009.

Knight, Bernard, CBE, MD, DM, PEKKA, Saukko, MD, Post Mortem Decomposition, Knight's Forensic Pathology, 3rd Edition, 2004

Lew, Emma, MD, MATSHES, Evan, MD, Post Mortem Changes, Forensic Pathology, Principles and Practice, 2005.

Personal Effects and Clothing Form (P-FORM-10.01)

PFPU Routine Ancillary Testing Standard Operating Procedure (P-PRO-FST-02.01)

Photography Standard Operating Procedure (P-PRO-PFPU-20.01)

Practice Manual for Pathologists, October 2009, Queen's printer for Ontario, 2009, Decomposed Cases.

Preparation for the Autopsy and Morning Rounds Standard Operating Procedure (P-PROPFPU-13.01)

Trace Evidence Standard Operating Procedure (P-PRO-PFPU-03.01)

6.6 HEALTH & SAFETY:

Universal Precautions are to be followed and appropriate Personal Protective Equipment must be worn at all times during postmortem examinations. Two or more persons are to be used to move a body. Additional staff may be required depending on body weight/size/or condition (i.e. decomposed). When using the ladder, one person must stand on the bottom step as an anchor.

6.7 MATERIALS:

Aerobic blood culture bottle

Anaerobic blood culture bottle

Autopsy identifier labels

Bacterial swab

Biohazard bag, yellow

Biohazard labels

Bleach

Blue top tube, with sodium citrate and sodium fluoride preservative, 15mL

Body bag

Cotton absorbent fill

Degreasing cleaner

Evidence bag

Gluteraldehyde, as required Jar,

glass, 100mL

Oscillating saw blade

Personal Effects and Clothing form

Pink top sterile container, plastic, 100mL

Push top polypropylene tube, 8mL (for collection of vitreous humour)

Scalpel blades, No. 22, disposable Sharps container, various sizes

Syringe, 5cc

Syringe, 10cc

Syringe, 60cc

Vacutainer collection tube, lavender top, with K_2-EDTA, 4mL

Viral specimen jars, with transport medium Viral swab

Virucidal cleaner

6.8 EQUIPMENT:

ABFO No.2 ruler

Autopsy suture needle

Bonney forcep (toothed)

Camera

Enterotomy scissor

Forcep, non-toothed

“L” reference scale

Label maker

Magnetic number board, black, plastic, 3” (with autopsy number)

Mayo dissecting scissor (blunt-blunt)

Oscillating saw

Paramedic scissor

Platform, yellow, 12”

Postmortem hammer

Rib cutter

Rongeur

Ruler

Scalpel handle, #4

Step ladder, 60”

Step stool, 8”

Virchow skull breaker

Viscera bucket

6.9 PROCEDURE:

NOTE: These procedures may be altered at the discretion of the pathologist if necessary. All postmortem examinations include a routine photoset. See Photography Standard Operating Procedure for required photographs. For collection and processing of samples for ancillary testing, see PFPU Routine Ancillary Testing Standard Operating Procedure.

a. Routine external examination

- **NOTE:** The external examination occurs during all postmortem examinations, however, some postmortem examinations are external examinations only (i.e. hangings) and this procedure is followed as well. Pathologists document all information about the deceased.

1. Before opening the body bag, notify the pathologist with the police seal number, if present, with the pathologist.

2. Upon opening the body bag, check the identification tag to ensure the identity of the deceased.

3. Take a routine overall photo of the deceased 'as is'. Remove any sheets, etc., that may be obscuring the body, but do not interfere with the body, if possible. Include the magnetic number board with appropriate autopsy number.

4. After pathologist completes their documentation, remove medical therapy and clothing. Remove items carefully and do not cut off the clothing unless directed by the pathologist.

5. Check all pockets for any personal items; place clothing in a yellow biohazard bag. The pathologist will document these items. **NOTE:** Never reach your hand directly into pockets. Always turn pocket from the outside in to reveal contents.

6. Personal items, if present, are to be cleaned and documented with the pathologist and on the Personal Effects and Clothing Form. They are placed in an evidence bag. (See section 0.9.1.1 for procedure)

7. Remove and discard all therapies except:
   - Urine Bag attached to Foley Catheter – collect urine for toxicology by opening the drain and filling a blue top tube. Once this is completed, bag can be discarded once emptied.
   - Endotracheal tube – cut tube with paramedic scissors at level of the mouth. Do not remove!
   - Blood transfusion bag – Detach the blood sample packet and submit with toxicology. Once blood sample packet is collected, bag can be discarded.

8. Measure the length of the body and relay this information to the pathologist.

9. Place the body face down (prone) onto the autopsy table and clean it by rinsing with warm water (and soap if necessary).

10. Take a routine overall photograph of the body in the prone position. Include the magnetic number board with appropriate autopsy number.

11. Assist the pathologist with the external examination of the body by following their directions.

12. Once the body is examined, place the body face up (supine).

13. Clean, photograph and examine the body. Assist the pathologist, if required. Include the magnetic number board with appropriate autopsy number for the photograph.

14. A routine photograph of the anterior close up of the face is taken. Include the "L" reference scale with appropriate autopsy number.

15. If only an external examination is warranted, samples for toxicology may be collected at this time

    a. Collect vitreous humour from the eyes:

        i. Rest the head on the head block
        ii. Using a 5cc syringe, insert the needle in the lateral side of the eye
        iii. Tilt the needle slightly downward at a 45° angle iv. Draw vitreous fluid slowly (as it is very viscous)
        v. Repeat with the other eye
        vi. Dispense the collected vitreous humour into the polypropylene push top tube
        vii. Carefully remove the needle from the syringe and discard in the sharps container. The syringe is to be discarded into the grey biohazard bin

    b. Collect heart blood:

        i. Using 100cc syringe, insert it into the jugular notch at a 45° angle
        ii. Draw blood slowly while moving the syringe slightly upward
        iii. Dispense into 15ml blue top tube
        iv. Carefully remove the needle from the syringe and discard in the sharps container. The syringe is to be discarded into the grey biohazard bin

    c. Collect urine:

        i. Using a 100cc syringe, insert it superior to the pubic symphysis
        ii. Draw urine into a syringe
        iii. Dispense into 15ml blue top tube
        iv. Carefully remove the needle from the syringe and discard in the sharps container. The syringe is to be discarded into the grey biohazard bin

    d. Collect femoral blood:

        i. Identify the anterior superior iliac spine and pubic symphysis
        ii. Palpate the inguinal ligament
        iii. Insert a 10cc syringe into the medial 1/3 (i.e. lateral to the pubic symphysis and inferior to the inguinal ligament) of the femoral triangle
        iv. Draw blood slowly into the syringe to prevent the vessel from collapsing
        v. Dispense into 15ml blue top tube
        vi. Repeat for other leg

vii. Carefully remove the needle from the syringe and discard in the sharps container. The syringe is to be discarded into the grey biohazard bin

6.9.1.1 Completing the Personal Effects and Clothing form

1. Place the autopsy identifier label on the form.

2. Under detailed description of valuables:
   - Describe personal effects that are present on the body. A description of the clothing is not required on the sheet.
   - When describing jewellery, use general terms like gold-coloured, silver-coloured, clear stones, etc., rather than specifics such as diamond, 24 carat, etc.
   - Ensure all personal effects are recorded.
   - Place items in evidence bag and seal it.
   - Place an autopsy identifier label on the outside of the evidence bag.
   - Record the seal number from the evidence bag in the appropriate area on the form.
   - If there are no personal effects, leave this area blank.
   - If monetary amount is $100 or over, these must be transferred to police.

3. Clothing disposition
   - Check the appropriate box.
     - Absent at autopsy or
     - Removed and returned with body or
     - Bag of clothing from hospital returned with body
   - Initial the appropriate box.

4. Ensure the pathologist initials the form to verify the information.

5. Valuables delivered to dispatch (FSTs to complete)
   - If valuables are present, initial only at the time the personal effects are transferred to Dispatch.

6.9.2 Routine internal examination

6.9.2.1 The Y incision

1. Make a Y incision into the torso, extending from the acromion process of each shoulder toward the midline of the body at the level of the 3rd rib. Make a vertical incision from the point where the two incisions meet at the 3rd rib and extending to the mons pubis.

2. Reflect the skin and soft tissue, including muscle, to expose the thoracic cage and abdominal organs. Use toothed forceps to create tension in the skin. This will reveal the fascia or the plane where the scalpel should follow.

6.9.2.2 Removal of chest plate and collection of heart blood

1. Depending on the age of the deceased, use the oscillating saw or a scalpel blade to remove the chest plate, exposing the thoracic cavity. When using the oscillating saw, score the area to be cut with a scalpel blade to ease the cutting with the saw. The oscillating saw does not cut through soft tissue easily. When using the scalpel blade, cut along the costochondral joints. Ensure the area exposed by the cut is wide enough for removal of the organ block.

2. Once the pleural cavities have been examined by the PA and pathologist, open the pericardium by making a cross-like incision using a scalpel or scissor to expose the heart.

3. Draw cardiac blood from the inferior vena cava (and/or superior vena cava and/or aorta and/or pulmonary trunk as alternatives) using a 10cc syringe and place in a blue top tube for toxicology. Collect a second sample of blood and keep safely in the syringe in the event of staff exposure or staff injury. **NOTE**: In the event of an accident to staff, this blood will then be sent for immediate testing by the FSTs. Carefully remove the needle from the syringe and discard in the sharps container. The syringe is to be discarded into the grey biohazard bin.

6.9.2.3 Removal of the intestines

1. Remove the bowel from the duodenum, at the Ligament of Trites, to the rectum. Once freed from the Ligament of Trites, cut the root of the mesentery that attaches the bowel to the posterior abdominal cavity wall to remove the small intestine. Make note of the appendix, if present. Remove the colon and transect at the rectum. **NOTE:** If the bowel is to be explored, it is advisable to string out the bowel to make it easier to open. Transect the bowel at the Ligament of Trites and remove the bowel by cutting the omentum closely along bowel while creating tension on the bowel.

6.9.2.4 Removal of neck organs

1. Reflect the skin and subcutaneous tissues of the chest and anterior neck up to the level of the mandible. Muscles are to be left in situ.

2. Insert the scalpel blade inferior to the angle of the mandible and incise along the inside curvature of the mandible. Using forceps or your hands, expose the tongue through this incision.

3. Remove the neck organs by incising along the sternocleidomastoid, through the omohyoid down to the spinal column on either side leaving the carotid arteries and thyroid in place. Be careful not to damage the carotid arteries, as these are essential to embalming preparation.

4. Grasping the end of the tongue with your hands, careful not to damage the neck structures, gently pull towards the feet of the deceased, using the scalpel or pair of scissors to free the organs from the cervical column.

6.9.2.5 Evisceration (Rokitansky Method)

1. Release the diaphragm by using a scalpel blade to cut along its attachments at the pleural cavity and the vertebral column.

2. Release the organ block further by scoring with a scalpel blade along the vertebral column below the vena cava.

3. Repeat on the other side. When scoring along the vertebral column ensure it is below the aorta.

4. Transect with a scalpel blade the femoral and the common iliac veins and arteries at the base of the lumbar spine.

5. Grasp the organ block below the neck structures or at the tongue, avoiding any damage to the neck structures. Use the scalpel to detach the organ block from the spinal column. Keep the blade horizontal to the vertebral column and using tension with the other hand pull the organs firmly away from the thoracic cavity towards the feet of the deceased.

6. Remove any excess blood in the thoracic cavity using a jar and place into the viscera bucket. Once cleaned, the thoracic cavity is inspected for any rib or spinal fractures. Document if there are any fractures present and inform the pathologist.

6.9.2.6 Pelvic organs

1. Using a 10cc syringe, collect urine sample for toxicology and place in a blue top tube. The total amount of urine in the bladder needs to be approximately measured, if present. Pierce the bladder using the scalpel and measure using a jar. Document the amount and inform the pathologist. Carefully remove the needle from the syringe and discard in the sharps container. The syringe is to be discarded into the grey biohazard bin.

2. Blunt dissect the pelvic organs in the extraperitoneal cavity.

3. Once free, transect the iliac vessels above the femoral canal using a scalpel.

4. Detach the pelvic organs at the bottom of the pelvic basin using a scalpel. For males, ensure the prostate (if present) is included with the pelvic organs. For females, ensure the ovaries (if present) are included with the pelvic organs. Be sure to not cut too deep into the rectum.

5. Incise with a scalpel the femoral artery and vein. Using a pink top container, collect blood from the femoral vein by firmly “milking” the leg toward the pelvic cavity. Place the femoral blood into one or two, depending on the amount of blood collected, blue top tube(s) clearly marked as Femoral with an “F”.

6.9.2.7 Scalp

1. Using a 5cc syringe, collect vitreous humour from the eyes for toxicology. Dispense the collected vitreous humour into the polypropylene push top tube. Carefully remove the needle from the syringe and discard in the sharps container. The syringe is to be discarded into the grey biohazard bin.

2. Part the hair from behind each of the ears and across the vertex of the head. Incise the scalp, using a scalpel, to the depth of the cranium from one mastoid process to the other across the apex of the head. Using either blunt dissection or a scalpel, reflect the scalp as anterior as the orbital ridge and as posterior as the external occipital protuberance.

3. Outline the borders of the temporalis muscle with a scalpel and reflect them laterally towards the scalp.

4. If necessary, scrape any periosteum/galea aponeurotica that may be left on the skull.

5. Call the pathologist to view the skull.

6.9.2.8 Calvarium

1. Cut with the oscillating saw through the skull bone all the way around the skull. Ensure that there is a large enough opening to remove the brain without damaging it.

2. Insert the Virchow skull breaker into the opening and twist to release the skull cap from the dura mater. On occasion, the dura may be difficult to release, therefore, scissors may be used to remove the dura by cutting along the venous sinus.

3. Insert a hand between the brain and the top of the calvarium. Using the other hand, remove the skull cap while gently supporting the brain with the other.

4. Call the pathologist to view the brain *in situ*.

6.9.2.9 Removal of the brain

1. Retract the olfactory bulbs in towards the base of the brain. Using a new scalpel blade cut the optic nerves, internal carotid arteries, and other cranial nerves.

2. Incise the tentorium cerebelli to free the cerebellum. Insert the scalpel deep in to the foramen magnum and cut far enough down the spinal cord to include the vertebral arteries.

3. Pull the brain away from the base of the skull. Place the brain in the viscera scale.

4. Using the Rongeurs, strip the dura mater from the base of the skull and the skull cap if any dura remains. Rinse the cranial cavity with water and remove the water.

5. Call the pathologist to view the base of the skull before closing.

6.9.2.10 Preparation for release of body

- See Completion of the Autopsy Standard Operating Procedure.

6.9.3 Criminally Suspicious Examination

NOTE: These examinations follow routine external and internal examinations with the following exceptions (listed below). However, under the discretion of the pathologist, certain procedures may change or be added. Ask the pathologist of their plan for the autopsy before it begins.

6.9.3.1 External examination

- X-rays may be required and will be completed before the autopsy begins. The ASC and/or PA will inform the Imaging Technician.

- If required by the pathologist, ALS may be used to see any evidence not visible with the naked eye.

- The collection of trace evidence will be decided by the pathologist and corresponding police agency if required. See the Trace Evidence Standard Operating Procedure steps on evidence collection and processing.

- During the external examination, clothing may be laid on a white sheet, if required by the pathologist or police agency, on the ground to be examined and photographed. Police will collect all personal effects and clothing and must sign off on the Personal Effects and Clothing form. Ensure that if any personal effects are present, they are written on the Personal Effects and Clothing form. **Do not wash or clean the personal effects, unless otherwise directed.**

6.9.3.2 Internal examination

- All criminally suspicious examinations require the bowel to be "strung out" and opened using enterotomy scissors for examination.

- See Trace Evidence Standard Operating Procedure on collection and management of foreign objects (e.g. bullets).

- Additional dissections may be required. See individual dissection standard operating procedures. ○ Anterior torso (layered) ○ Anterior neck ○ Posterior torso (layered) ○ Posterior neck ○ Removal of vertebral arteries ○ Lower extremities, including ankles ○ Upper extremities, including wrists ○ Pelvic exenteration ○ Removal of testes ○ Removal of spinal cord

6.9.4 Death under 5 years of age examination

NOTE: These examinations follow routine external and internal examinations with the following exceptions.

6.9.4.1 External examination

- Complete a full skeletal x-ray survey prior to the postmortem examination. Prior to the x-rays any personal effects, clothing and medical therapy will be documented, photographed and removed in the presence of the pathologist.

- Take the following measurements once x-rays are completed. These include:

    - Crown to heel
    - Crown to rump
    - Head circumference
    - Chest circumference (at the level of the nipples)
    - Abdominal circumference (at the level of the umbilicus)
    - Length of each foot
    - Accurate weight of body (use infant scale)

6.9.4.2 Internal examination

1. Perform a layered dissection of the anterior torso. See Dissection of Anterior Torso Standard Operating Procedure.

2. Once anterior chest plate is removed, collect bacterial and viral lung cultures. Use a sterile scalpel blade to cut into a lung lobe, and with a sterile needle and sterile scalpel take two sections of the internal lung. Put the first section into a viral container and a second section into a bacterial container.

3. Collect blood cultures and blood for routine toxicology. **Do not remove the bowels until blood cultures are taken.**

    - Blood for culture is placed in a pediatric bacterial culture bottle with transport medium.
    - Blood for possible future genetic testing is placed in EDTA tube.
    - Blood for metabolic screening for the Ontario Newborn Screening Program is blotted on a Whatman 903 collection card.
    - Blood for routine toxicology is collected in blue top tube.

4. Leave neck structures in situ in order to do separate layered neck dissection after brain is removed. Routinely eviscerate the body.

5. Open the bowel using enterotomy scissors and/or scissors.

6. Once organ block is removed, collect cerebrospinal fluid before brain is removed. Reflect the psoas muscle on one side of spinal column. Slowly insert a 10cc syringe posteriorly through a disc in the lumbar region of the spinal column and aspirate up to 10ml of clear cerebrospinal fluid. Place in a red top vacutainer tube.

7. Removal of the brain can be done routinely or by the petal method if infant is under 2 months old. See Brain Fixation Standard Operating Procedure for later dissection of the brain.

8. Remove the pituitary gland.

9. Remove orbital plates in order to visualize optic nerve sheath. If optic nerve hemorrhage is present, remove the eyes and place in separate containers of formalin (right eye and left eye). If no hemorrhage is present, vitreous humour is collected.

10. Remove petrous bone in order to visualize inner ear canals.

11. Perform a layered dissection of the anterior neck.

12. Remove testicles and collect a sample for the stock jar.

13. Collect a section of psoas muscle for the stock jar.

14. Collect a section of rib at costochondral junction for the histology jar.

15. Collect submandibular gland for the stock jar.

16. Perform a layered dissection of the posterior torso.

17. Perform a layered dissection of the posterior neck.

18. Remove spinal cord and place in the same container of 10% buffered formalin as brain and dura.

19. Take sample of cartilage from heel or ribs and place in blue top tube with fibroblast transport medium.

6.9.5 Decomposed and mummified examination

- The general stages of decomposition are fixed with two stages of chemical decomposition: autolysis and putrefaction. These two stages contribute to the chemical

process of decomposition, which breaks down the main components of the body. The four types of decomposition are:

i) Autolysis: More commonly known as self-digestion, refers to the destruction of a cell through the action of its own enzymes.
ii) Putrefaction: It is the result from post mortem bacterial proliferation (decomposition of protein by anaerobic microorganisms) with gas formation. The gas formation causes bloating of the tissues externally and internally.
iii) Adipocere/Saponification: A waxy substance derived from the body fat. The substance itself is off-white, but staining with blood or products of decomposition can give it the red or greenish hues.
iv) Mummification: Drying of the tissues in place of liquefying putrefaction. Mummification can coexist along with putrefactive decomposition in other areas of the same body.

- Routine procedures are to be followed when handling these remains, unless criminally suspicious. However, extra care is to be taken so as not to disturb the body and create further skin slippage.

- While washing the body and under the supervision of the Forensic Pathologist, note marks, scars (surgical/accidental), bruises, perforations, fractures, dislocations, tattoos, abrasions, etc.

- Be aware and maintain a safe clean working environment and remove with water any putrefactive fluid(s) that might interfere with the handling of the instruments or the remains.

- Unless directed differently by the forensic pathologist, the routine Y incision must be performed to achieve the evisceration. In some cases, an incision from the angle of the mandible down to the mons pubis can be used if skin is too difficult to reflect and expose the neck organs.

- The brain may be in a liquefied state and the brain is to be placed in a plastic bag for collection. It is recommended to call the pathologist before the calvarium is removed so they may visualize the brain *in situ* when it is being removed.

- The collection of blood, urine and vitreous humour for toxicology can be a challenge. Try to collect routine toxicology samples.

- Degreaser can be used to assist in the removal of putrefactive film on the autopsy table and instruments.

- The pathologist and the forensic anthropologist may divert from this protocol to document injuries or trauma not visible during the autopsy. In certain cases, the remains may be skeletonized to remove the connective and muscular tissues to reveal antemortem artifacts or injuries. In this case, the directions will be provided by the forensic anthropologist to achieve the next level of examination.

6.9.6 Infectious examination

NOTE: The known hazardous autopsy requires a few extra steps than a routine external and internal postmortem examination. All appropriate PPE should be used along with a PAPR for highly infectious cases. Once PPE is put on, a minimum number of personnel are to be present in the postmortem room. If possible, the postmortem examination should be completed in a separate ventilated room with the use of personal respiratory equipment. It is imperative to ensure proper cleaning protocols are followed to disinfect the exposed areas once the examination is complete. Listed below are examples of hazardous cases.

- Creutzfeld-Jacob Disease (CJD) is rare, but is the most common progressive neurodegenerative disease. There are three main categories: sporadic, hereditary, and acquired. It occurs when a normal brain protein spontaneously changes into an infectious abnormal form called a “prion” and accumulates in brain cells. CJD is only transmitted through contact with infected tissues.

- HIV and Hepatitis, like most blood-borne pathogens, are contracted through blood interaction. In cases of known or suspected HIV or hepatitis infection, a minimum number of staff should cut or handle organs during the postmortem examination. Place biohazard labels on body bag, stock jar, histology jar and any other samples taken in order to inform other people who will come into contact with any biological material from the postmortem examination.

- Influenza is transmitted through air borne particles, therefore, the oscillating saw should be used sparingly and the number of people present during the postmortem examination should be kept to a minimum. The following protocol is intended to fully

assess both the typical influenza A associated pathology/microbiology in conjunction with a full cardiovascular pathology consultation. The heart and lungs (and any other organs with gross abnormality) from each case will be photographed. If the case is a child under 5 years of age, follow the DU5 protocol with additional sections and cultures as noted below.

i) All autopsies to include

1. vitreous biochemistry
2. myocardial and lung tissue in 2% gluteraldehyde for electron microscopy.

ii) Specimens for culture (**Note:** all specimens are to be stored at 4^{o}C and subsequently sent to Public Health ASAP)

1. Nasopharyngeal swab (viral)
2. Fluid Cultures
   - Pericardial fluid
   - Aerobic and anaerobic blood cultures
   - Whole blood (in EDTA)
   - Urine
   - Bowel contents, 5mL
3. Tissue samples (one for viral testing and one for bacterial testing) (*optional)
   - Nasopharyngeal swab of trachea
   - Trachea – proximal
   - Trachea – distal
   - Right principle bronchus
   - Left principle bronchus
   - Right central lung tissue with lobar bronchus
   - Left central lung tissue with lobar bronchus
   - Peripheral lung tissue from right lung
   - Peripheral lung tissue from left lung

- Grossly abnormal lung tissue
- Pericardium
- Enlarged lymph node
- Spleen
- Small bowel
- Large bowel
- Right ventricle
- Left ventricle
- Cerebral cortex*
- Basal ganglia*
- Pons*
- Medulla*
- Cerebellum*
- Meninges*
- Spinal cord*
- Liver*
- Kidney*
- Adrenal gland*

- Meningitis is the inflammation of the membranes surrounding the brain and spinal cord. It can be transmitted two ways: bacterially and virally. Viral meningitis is the most common form seen during a postmortem examination. However, bacterial meningitis can be detected and is considered more likely to be transmitted. Meningitis can be transmitted through aerosols, splashes, cuts and/or needlestick injuries. It is seen as a layer of mucus encompassing the brain upon removal of the skull cap. However, there may be indications of meningitis externally as a skin rash or internally before removal of the skull as adrenal haemorrhages, or any type of head

infection (i.e. tooth abscess, sinus and ear infections). If you suspect meningitis is present, bring it to the attention of the forensic pathologist. At the discretion of the pathologist viral and bacterial swabs are taken of the mucus to send for ancillary testing.

- Tuberculosis is transmitted through air borne particles. It is advised to use the oscillating saw as minimally as possible during a potential case of TB since bone dust can carry bacteria and be inhaled.

6.9.7 Chemically hazardous examination

NOTE: Routine external and internal postmortem examination procedures are to be followed. The pathologist will take the necessary steps in determining the proper procedures are followed.

- The location of the autopsy will be determined by the Pathologist.
- Universal Precautions must be followed at all times and full PPE worn.
- Those involved in the autopsy will be kept to a minimum.

REVISION HISTORY:

Version	Date Effective	Authorized By (Name/Position)	Initials	Revision Summary

APPENDIX II

Keywords

Causes of Death:

Undetermined

Heart Failure

Metabolic Acidosis

Herpes Simplex Virus

Acute Asthmatic Attack

Chronic Compressive Myelopathy

Acute Cardiac Failure

Cardiorespiratory Complications

Respiratory Syncytial Virus

Upper Airway Obstruction

Complications of Respiratory Infection

Perinatal Asphyxia

Complex Congenital Heart Disease

Overlay

Acute Respiratory Failure

Drowning

Multi-Organ Dysfunction Syndrome

Developmental Field Defects

Streptococcus Pyogenes Infection

Hypoxic Ischemic Encephalopathy

Ketoacidosis

Complications of Burn Injury

Pseudoephedrine Toxicity

Head Injury

Total Anomalous Pulmonary Venous Return

Hemopericardium

Cardiomegaly

Cardiopulmonary Complications of Trisomy 21

Salmonella Osteomyelitis

Acute Bronchopneumonia

Klebsiella Oxytoca Sepsis

Mitochondrial Complex IV Deficiency

Positional Asphyxiation

Digeorge Syndrome

Acute Pyelonephritis

Dehydration due to Acute Gastroenteritis

Upper Respiratory Complications of Treaceo-Esophageal Fistula

Complications of Lower Respiratory Tract Infection

Sudden Unexpected Death in Epilepsy

Necrotizing Enterocolitis

Acute Meningococcemia

Klebsiella Pneumoniae Septicemia

Complications of Sepsis Related Seizures

Malnourishment and Dehydration

External Neck Compression

Cardiac Fibroma

Interstitial Myocarditis

Small Bowel Obstruction due to Peritoneal Fibrous Adhesions

Neuro-Endocrine Complications of Septo-Optic Dysplasia

Heat Exposure or Exhaustion

Smothering

Streptococcus Pyogenes Group A Sepsis

Haemophilus influenzae Sepsis

Intussusception

Influenza A Infection of the Respiratory Tract

Rheumatic Pancarditis

Idiopathic Hypertrophic Cardiomyopathy

Exsanguination

Pneumonia due to Remote Hypoxic Ischemic Encephalopathy

Hypoxic Ischemic Sequelae

Enterococcal Septicemia

Sudden Infant Death Syndrome

Cardiorespiratory Complications of a Chronic Neuro-Development Disorder

Hypoplastic Left Ventricle of the Heart

Acute Pneumonia in a Resuscitated Child

Complications of Asthma and Malnutrition

Chronic Epicarditis

Submandibular Soft Tissue Abscess due to Staphylococcus Aureus Infection

Complications of Familial Skeletal Myopathy

Bacteria:

Staphylococcus aureus

Streptococcus viridians

Staphylococcus epidermidis

Coagulase Negative Staphylococcus

Streptococcus mitis

Enterococcus faecalis

Escherichia coli

Streptococcus parasanguinis

Streptococcus salivarius

Candida albicans

Bacillus sp.

Micrococcus sp.

Streptococcus oralis

Enterobacter cloacae

Streptococcus vestibularis

Klebsiella/Raoultella sp.

Bifidobacterium sp.

Citrobacter freundii

Coliform sp.

Non-haemolytic Saccharolytic Acinetobacter sp.

Non-haemolytic Asaccharolytic Acinetobacter sp.

Enterococcus sp.

Klebsiella oxytoca

Streptococcus pneumoniae

Leuconostoc lactis

Serratia marcescens

Lactococcus lactis

Gram Positive Bacillus

Gram Negative Bacillus

Stenotrophomonas maltophilia

Streptococcus agalactiae

Group B Streptococcus

Neisseria sp.

Leuconostoc sp.

Hafnia alvei

Aeromonas hydrophila

Aeromonas sp.

Clostridium bifermentans

Streptococcus sp.

Moraxella catarrhalis

Neisseria lactamica

Kocuria varians

Pseudomonas aeruginosa

Enterococcus faecium

Group A Streptococcus

Streptococcus agalactiae

Lactobacillus sp.

Haemophilus influenzae

Gemella sp.

Klebsiella pneumoniae

Bacteroides uniformis

Clostridium difficile

Clostridium ramosum

Candida parapsilosis

Blastocystis hominis

Alpha Hemolytic Streptococcus

Candida guilliermondii

Haemophilus parainfluenzae

Neisseria sicca

Citrobacter koseri

Lactococcus garvleae

Leuconostoc mesenteroides

Lactococcus sp.

Leuconostoc sp.

Candida glabrata

Streptococcus dysgalactiae

Bacillus cereus

Granulicatella adiacens

Bacteroides fragilis

Salmonella dublin

Streptococcus pyogenes

Enterobacter sp.

Staphylococcus hominis

Streptococcus gordonii

Rothia mucilaginosa

Enterococcus avium

Raoultella planticola

Corynebacterium sp.

Bifidobacterium sp.

Kluyvera ascorbata

Weissella sp.

Weissella confusa

Campylobacter upsaliensis

Candida tropicalis

Candida dubliniensis

Kluyveromyces marxianus

Neisseria meningitis

Bifidobacterium breve

Corynebacterium pseudodiphtheriticum

Streptococcus infantarius

Lactobacillus crispatus

Clostridium perfringens

Clostridium sp.

Aerococcus sp.

Proteus vulgaris

Serratia marcenscens

Bordetella parapertussis

Streptococcus anginosus

Kluyvera cryocrescens

Enterobacter gergoviae

Pantoea sp.

Enterococcus durans

Diphtheroid bacilli

Non-hemolytic Streptococcus

Clostridium sordelli

Mucor sp.

Proteus mirabillis

Escherichia hermanii

Mycoplasma pneumoniae

Neisseria subflava biovar perflava

Klebsiella planticola

Streptococcus pneumoniae

Citrobacter sedlakii

Diphtheroid sp.

Enterococcus casseliflavus

Bifidobacterium longum

Citrobacter amalonaticus

Bacteroides vulgatus

Bacteroides sp.

Pantoea agglomerans

Finegoldia magna

Veillonella sp.

Penicillium sp.

Morganella morganii

Serratia plymuthica

Streptococcus bovis

Staphylococcus lugdunensis

Enterococcus gallinarum

Enterobacter aerogenes

Staphylococcus simulans

Bacillus megaterium

Proteus mirabilis

Beta hemolytic Streptococcus

Staphylococcus sp.

Campylobacter jejuni

Campylobacter coli

Staphylococcus capitis

Enterococcus dufans

Citrobacter youngae

Haemophilus sp.

Lactococcus garvieae

Viruses:

Herpes Simplex Virus 2

Rhinovirus

Respiratory Syncytial Virus A	Parainfluenza 2
Influenza A	Parainfluenza 1
Respiratory Syncytial Virus B	Metapneumovirus
Enterovirus	Paraunfluenza 3
Bocavirus	Corona virus 229E/NL63
Influenza B	Rotavirus
H1N1	Parainfluenza 4
Adenovirus	Cytomegalovirus

APPENDIX III

Correlations

Cause of Death and Bacteria/virus:

Chronic Compressive Myelopathy and Klebsiella/Raoultella sp.

Chronic Compressive Myelopathy and Bifidobacterium sp.

Complications of Respiratory Infection and Gram Negative Bacillus sp.

Perinatal Asphyxia and Gram Positive Bacillus sp.

Pseudoephedrine Toxicity and Klebsiella/Raoultella sp.

Hemopericardium and Neisseria sicca

Hemopericardium and Citrobacter koseri

Hemopericardium and Parainfluenza 3

Salmonella Osteomyelitis and Bacteroides fragilis

Salmonella Osteomyelitis and Salmonella dublin

Salmonella Osteomyelitis and Parainfluenza 3

DiGeorge Syndrome and Kluyvera ascorbata

DiGeorge Syndrome and Weissella sp.

DiGeorge Syndrome andWeissella confusa

Complications of Lower Respiratory Tract Infection and Campylobacter upsaliensis

Complications of Lower Respiratory Tract Infection and Candida tropicalis

Complications of Lower Respiratory Tract Infection and Kluyveromyces marxianus

Acute Meningococcemia and Neisseria meningitis

Malnourishment and Dehydration and Lactobacillus crispatus

Interstitial Myocarditis and Aerococcus sp.

Heat Exposure/Exhaustion and Serratia marcenscens

Heat Exposure/Exhaustion and Bordetella parapertussis

Chronis Epicarditis and Aerococcus sp.

Cardiorespiratory Complications and Enterobacter aerogenes

Herpes Simplex Virus and Herpes Simplex Virus 2

Respiratory Syncytial Virus and Respiratory Syncytial Virus B

Intussusception and Escherichia hermanii

Intussusception and Mycoplasma pneumoniae

Intussusception and Neisseria subflava biovar perflava

Influenza A Infection of the Respiratory Tract and Citrobacter sedlakii

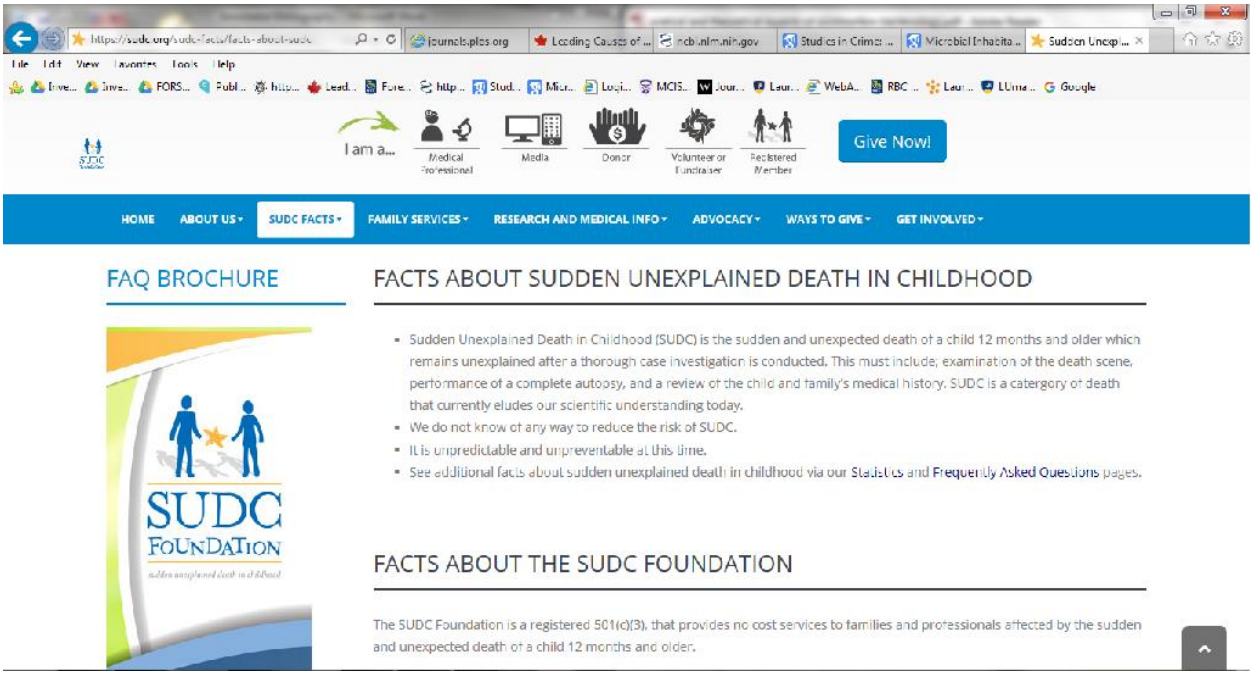
Enterococcal Septicemia and Penicillium sp.

Cardiorespiratory Complications of a Chronic Neuro-development Disorder and Enterobacter aerogenes

Rheumatic Pancarditis and Beta Hemolytic Streptococcus

APPENDIX IV

Websites


I am a...
Medical Professional
Media
Donor
Volunteer or Fundraiser
Registered Member
Give Now!
HOME
ABOUT US
SUDC FACTS
FAMILY SERVICES
RESEARCH AND MEDICAL INFO
ADVOCACY
WAYS TO GIVE
GET INVOLVED
FAQ BROCHURE
SUDC
FOUNDATION
FACTS ABOUT SUDDEN UNEXPLAINED DEATH IN CHILDHOOD
Sudden Unexplained Death in Childhood (SUDC) is the sudden and unexpected death of a child 12 months and older which remains unexplained after a thorough case investigation is conducted. This must include; examination of the death scene, performance of a complete autopsy, and a review of the child and family's medical history. SUDC is a catergory of death that currently eludes our scientific understanding today.
We do not know of any way to reduce the risk of SUDC.
It is unpredictable and unpreventable at this time.
See additional facts about sudden unexplained death in childhood via our Statistics and Frequently Asked Questions pages.
FACTS ABOUT THE SUDC FOUNDATION
The SUDC Foundation is a registered 501(c)(3), that provides no cost services to families and professionals affected by the sudden and unexpected death of a child 12 months and older.

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Infant mortality rates, by province and territory (Both sexes)

	2009	2010	2011	2012	2013
			Both sexes		
Canada	**4.9**	**5.0**	**4.9**	**4.8**	**4.9**
Newfoundland and Labrador	6.3	5.3	6.3	5.5	6.6
Prince Edward Island	3.4	3.6	4.2	3.5	2.3
Nova Scotia	3.4	4.6	4.9	4.6	3.3
New Brunswick	5.8	3.4	3.5	5.7	4.7
Quebec	4.4	5.0	4.5	5.0	4.9
Ontario	5.0	5.0	4.7	4.9	4.8
Manitoba	6.3	6.7	7.7	5.9	5.7
Saskatchewan	6.7	5.9	6.8	5.5	7.4
Alberta	5.5	5.9	5.2	4.3	5.3

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